

TM. 7/1958

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7/1958

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FUEL RESEARCH INSTITUTE OF SOUTH AFRICA.

TECHNICAL MEMORANDUM NO. 7/1958.

THE DETERMINATION OF THE AIR-DRIED MOISTURE  
CONTENT OF PREPARED COAL FROM THE COLLIERIES: SPRINGBOK,  
NAVIGATION (S.A.C.E) AND BLESBOK

BY

A.J. PETRICK

See also 10/58

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INTRODUCTION:

The agreements between the collieries supplying blend coking coal to Iscor provide for the purchase of this coal in the air-dry condition. Therefore, weighbridge tonnages must be converted to "tons of air-dry coal."

The "surface" or "free" moisture content of the coal as weighed, is obtained by taking samples regularly. These samples are dried, ultimately at 108°C, yielding a "total moisture value" from which the air-dry moisture is deducted<sup>1)</sup> to arrive at the "surface" or "free" moisture value.

This air-dry moisture value is determined periodically (formerly at six monthly intervals) and the value obtained remains in force until the next determination is done.

Recent values for the air-dry moisture content were much lower than those found in earlier years and the Institute was asked to investigate the matter.

Some/.....2.

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1) Direct deduction, if actually practiced, is not strictly permissible for assume total moisture 10% and air-dry moisture 2%; then 100 grams of wet coal as weighed at weighbridge contain 90 grams of bone dry coal. These 90 grams in air-dried state should weigh  $90 \times \frac{100}{98} = 91.8$  grams and surface moisture is therefore  $\longrightarrow 100 - 91.8 = 8.2$  grams and not  $10 - 2 = 8$  grams.

SOME GENERAL CONSIDERATIONS.

1. The capacity of a coal to retain moisture in equilibrium with the atmosphere to which it is exposed is an intrinsic property of the coal depending on its micro structure and micro surface properties.

Therefore, the particle size of the coal as received has no appreciable effect on this property - its main effect would be to affect the speed at which equilibrium is attained.

2. The micro structure and accessible surface may be affected by excessive drying so that a coal, once dried beyond a certain level, is no longer capable of retaining as much moisture as the same coal freshly mined - both being exposed to an atmosphere of the same relative humidity.

Therefore, a sample of coal should never be allowed to dry out too much prior to conditioning if the "air-dry" moisture content of freshly mined coal is to be determined.

3. In as much as the "air-drying" or "conditioning" process is conducted to establish equilibrium between the moisture retained in the coal and that in the surrounding atmosphere, it will be appreciated that the amount of moisture retained in the coal will be affected by the relative humidity of the surrounding atmosphere. (Less mature, more porous coal is more sensitive in this respect).

Some typical/.....3.

Some typical results illustrating this point were obtained at the Institute in 1951.

TABLE 1.

Relation between the Relative Humidity of the surrounding atmosphere and the determined air-dry moisture content of some coals (all -20 mesh B.S.S.)

Coal.	Relative Humidity of surrounding Atmosphere.	Moisture Content Determined.
Vryheid Coronation.	{ 100	2.3
	{ 67	2.0
	{ 33	1.1
	{ Avg. Laboratory.	1.1
Navigation S.A.C.E.	{ 100	4.4
	{ 67	2.9
	{ 33	2.2
	{ Avg. Laboratory	2.3
Springbok No. 2.	{ 100	4.6
	{ 67	3.6
	{ 33	2.6
	{ Avg. Laboratory	2.6
Cornelia	{ 100	11.4
	{ 67	9.4
	{ 33	7.3
	{ Avg. Laboratory	8.6

It is understood that the Iscor contracts stipulate air-drying under average relative humidity conditions. For Pretoria this annual average is about 55% according to the Weather Bureau and it is probably of this order in Witbank. However, a variation of relative humidity between say 45% - 65% would not affect the air-dried moisture value of the Witbank coals very appreciably (See Table 1).

4. The temperature of the surroundings will also affect the amount of moisture retained by the coal during conditioning but it is accepted here that the temperature in the conditioning laboratories will not vary excessively so that this effect may be neglected.
5. Nearly all coals lose moisture on exposure to air during crushing. With fine crushing to say 60 mesh this may be aggravated by the rather more intensive air currents and the generation of heat.

The B.S. specification B.S. 1016 Part I, 1957 therefore stipulates that "where it is necessary to reduce the bulk weight and particle size during the preparation of the sample for total moisture determination, air-drying must be carried out before crushing to pass either a  $\frac{1}{2}$  inch square mesh or a 6 mesh B.S. test sieve. The only exception to this is visibly dry high-rank coal which may be crushed to the  $\frac{1}{2}$  in. size without loss of moisture. Where crushing to  $\frac{1}{2}$  inch is not necessary e.g.  $\frac{1}{2}$  in. washed smalls, the laboratory sample may be received without previous air-drying."

Although total moisture determination is not considered in this report, the above quotation is included to indicate the reason why the B.S. Specifications provide for air-dried moisture content to be determined on  $\frac{1}{2}$  inch or 6 mesh B.S. coal.

The high rank coals referred to are arbitrarily defined as "coals containing less than 4 per cent moisture (in air-dried coal)". In this sense the coals under consideration in this report may be considered high rank and some crushing is admissible.

GENERAL PROCEDURE AT THE INSTITUTE  
FOR DETERMINING THE AIR-DRIED MOISTURE CONTENT.

The Institute seldom does total moisture on coal samples procured in the course of survey, grading or other investigations.

It is usual, however, to allow samples of visably wet coal to air-dry sufficiently to facilitate crushing, screening and sample division.

Care is taken not to dry the samples excessively.

Although the B.S. Specification provides for determining the air-dry moisture content on minus  $\frac{1}{2}$  inch coal (a 2 lb. sample is used) this is usually not done at the Institute. The semi-air-dried sample is crushed and reduced in bulk until a 30 mesh or 60 mesh laboratory sample is available. Some moisture may be lost in this process but the sample is placed in this fine state in the conditioning laboratory for 24 hours. If it has not been dried excessively it should recover any "air-dried moisture" lost.

The moisture content of this laboratory sample is subsequently determined either by using the toluene distillation method (Dean & Stark Apparatus) or by drying in a vacuum drying oven maintained at 108°C.

In the latter case a test sample of small weight is involved that can conveniently be cooled in a dessicator after removal from the drying oven.

The procedure/.....6.

The procedure is rapid and convenient. At its worst one would expect the values to be somewhat low (compared to fresh coal) because the micro structure or surface may have been affected by the drying during crushing and handling before final air conditioning.

PROCEDURE ADOPTED AT THE ISCOR CONTROL LABORATORY  
(Navigation)

The procedure was described as follows by a senior member of the laboratory staff:

"On arrival at the laboratory, the moisture sample is spread out on a concrete slab, provided with a cawling, in the laboratory.

It is allowed to air-dry in this room - a period of ten hours was considered adequate.

Thereafter the sample is crushed to minus  $\frac{1}{4}$  inch by passing it twice through a small jaw crusher. A sample of 2 lb. is then cut out and transferred to a shallow pan where it is spread out to form a thin layer. The sample is dried in an electrically heated drying oven maintained at  $108^{\circ}\text{C}$  to constant weight ( 4 hours) and weighed."

In principle this method conforms with the requirements of the B.S. Specification and a similar procedure was used as one alternative in the subsequent study at the Institute. The large tray (15" x 10") cannot be cooled conveniently in a dessicator and the tray with coal must be weighed hot, as the coal absorbs moisture again if allowed to cool in the laboratory atmosphere. This "hot weighing"

is also/.....7.

is also stipulated in the B.S. Specification 1016/Pt.1/1957.

MOISTURE DETERMINATION ON NAVIGATION SAMPLES  
TAKEN AND AIR-DRIED BY OFFICERS OF ISCOR.

By arrangement with the Iscor laboratory at Navigation Colliery, five samples of coal, air-dried and crushed to minus  $\frac{1}{4}$  inch were halved. Moisture determinations were done by the Iscor laboratory staff on one half and the other was made available to the Institute.

On arrival at Pretoria, a portion of each sample was cut out, ground to minus 60 mesh and the moisture content was determined in the usual way.

The balance of four of the samples was used for moisture determination as described by the Iscor laboratory staff. (Drying 4 hours at  $108^{\circ}\text{C}$ ). After drying, the samples were weighed hot and again after cooling to room temperature. The gain in weight during cooling represented about 0.3% on the weight of the sample. (The "hot weight" was therefore used to determine the actual moisture content). The balance of the fifth sample was placed in a tray in the "conditioning" laboratory for  $15\frac{1}{2}$  hours. The weight increase was only 0.07% so that it appears that the relative humidity conditions in the two laboratories were similar and that the sample had been air-dried sufficiently long to reach equilibrium.

The sample was then halved. A portion of one half was used for the moisture determination by the toluene method while another portion was dried in a moisture oven at  $105^{\circ}\text{C}$ .

The other half/.....8.



The other half of this sample was crushed to minus 20 mesh. Part of the crushed coal was air-dried in a laboratory without air conditioning while the other was air-dried in the conditioning laboratory. A small gain in weight occurred - probably moisture lost during crushing. Portions of these samples were then used for moisture determination by (a) heating in the vacuum drying oven and (b) by the toluene distillation method.

The moisture content on the  $\frac{1}{4}$  inch portions was found at: Drying in oven ... .. 2.3%  
Toluene method ... .. 2.0%

That on the -20 mesh coal yielded values of 2.3 and 2.4%.

The results obtained on these samples are given in Table 2.

TABLE 2.

Air-dried Moisture content of Navigation Samples (taken by Iscor Staff).

Sample.	Determined on $-\frac{1}{4}$ coal.		Determined on -20 mesh coal.	Determined on -60 mesh coal.
	Iscor Lab.	F.R.I.	F.R.I.	F.R.I.
A	2.3	3.1	-	2.6
B	2.6	2.5	-	2.6
C	2.5	2.3	2.3	-
D	2.5	2.6	-	2.6
E	2.5	2.4	-	2.6

The results/.....9.

The results are reported to the first decimal place only as there is no object in giving the second decimal place. The results, with the exception of Sample A, are in good agreement.

By comparison with the Institute's normal procedure the air-drying of coarse coal and its subsequent drying and weighing is much more tedious and inconvenient so that, while good agreement was obtained, the Institute would prefer its normal procedure.

STUDY OF SAMPLES TAKEN BY THE INSTITUTE  
AT NAVIGATION, SPRINGBOK & BLESBOK COLLIERIES.

The following samples were taken at the washing plants of these collieries.

TABLE 3.

<u>Samples Studied.</u>	
Springbok Colliery	: Washed Nuts and Washed Fines.
Blesbok Colliery	: Washed coarse and washed fines.
Navigation	: Mixed product as loaded into bins.

No total Moisture contents were determined on these samples.

On arrival at Pretoria each bulk sample was thoroughly mixed and ten 2 lb. increments were taken from it to constitute a sample for investigation. Two such samples for investigation were taken. They were spread out in 3' x 3' trays. One sample was air-dried under "uncontrolled humidity" conditions while the other was air-dried in the conditioning laboratory. From time to time the coal was transferred to a suitable container for weighing and then returned to the tray.

The coarse coal/.....10.

The coarse coal was practically "air-dry" in about 10 hours, but the coal containing fines had probably not quite reached equilibrium even after 22 hours.

CRUSHING AND REDUCTION.

After 22 hours air-drying, the samples were crushed to minus  $\frac{1}{4}$  inch in a small Sturtevant mill.

Duplicate 2 lb. samples were then cut from each sample, transferred to 12" x 12" trays and dried in an electrically heated drying oven.

Samples of about 1 lb. were cut for determining moisture by the toluene distillation method.

Samples were also cut out of the air-dried sample for crushing to minus 60 mesh and determination of moisture on this size grade. This was unfortunately done at a later stage when the coal had been standing for some time under the drier conditions prevailing in Pretoria during February. This may account for the lower results obtained. The results of the various methods for determining the air-dried moisture content of the samples are given in Table 3.

In this table, the "A" group refers to samples air-dried in a room with no special temperature and relative humidity control. "C" refers to samples air-dried in the air conditioned laboratory.

TABLE 4./.....11.

TABLE 4.

Air-dried Moisture Content of Samples.  
Product Samples.

Sample.	A GROUP.		C GROUP.		60 Mesh Lab. Sample.	Avg. Figure on Product Samples F.R.I. Annual Report 1956.
	Heating 108°C	Toluene Dist.	Heating 108°C	Toluene Dist.		
Springbok Washed Nuts )	3.0	2.9	3.0	2.6	2.3	-
Springbok Washed Fines )	3.1	2.8	2.7	3.2	Not determined	-
Blesbok Washed Coarse )	3.0	2.8	3.2	n.d.	2.7	3.0
Blesbok Washed fines )	5.0	4.5	4.5	n.d.	2.9	3.0
Navigation Mixed )	2.7	2.8	2.7	n.d.	2.1	2.5

By comparison with values obtained on the  $-\frac{1}{4}$  inch coal, the values obtained by the laboratory method (60 mesh coal) are consistently somewhat low on these samples. Other product samples have given higher results agreeing with those obtained on the  $-\frac{1}{4}$  inch coal reported in Table 3.

It appears that the values for the Blesbok washed Fines on  $-\frac{1}{4}$  mesh coal are too high probably because of insufficient air drying.

SUMMARY AND CONCLUSION:

1. A number of samples of Navigation Collieries' product were analysed to determine the inherent moisture content. The results were fairly consistent in the neighbourhood of 2.5%.
2. Experiments on product samples from Navigation, Springbok and Blesbok Collieries suggest that the coarser coal (from +  $\frac{5}{8}$ " upwards) can be air-dried quite rapidly but the finer coal if spread out in a layer of more than about  $\frac{3}{4}$ " thickness may, due to the high percentage of surface moisture present, require over 24 hours exposure in the laboratory to become air-dry.
3. The method of determining the air-dried moisture content of coal by heating minus  $\frac{1}{4}$  inch coal, although in accordance with accepted specifications, is fairly tedious and provides a practical difficulty of weighing a fairly large bulk of coal hot unless special equipment is obtained to let the coal cool in an absolutely dry atmosphere.
4. The laboratory method generally used at the Institute has the advantage that a relatively small laboratory sample can be handled. It can be air-dried in a relatively short time and the final drying in the oven is also completed in a short time.

Although it may yield slightly low results, this method is preferred.

5. As far as/.....13.

5. As far as the Institute can establish, the air-dried moisture content of coal from any of the seams mined in a particular colliery is fairly consistent over an extended period. The moisture content of coal from the No. 5 Seam is generally somewhat higher than that of the No. 2 Seam.

If, therefore, in a case such as Navigation (S.A.C.E.) the proportion of No. 5 Seam mined increases, one would expect the average air-dried moisture content of the product to increase somewhat.

A.J. PETRICK.

DIRECTOR.

2/4/1958.  
PRETORIA.